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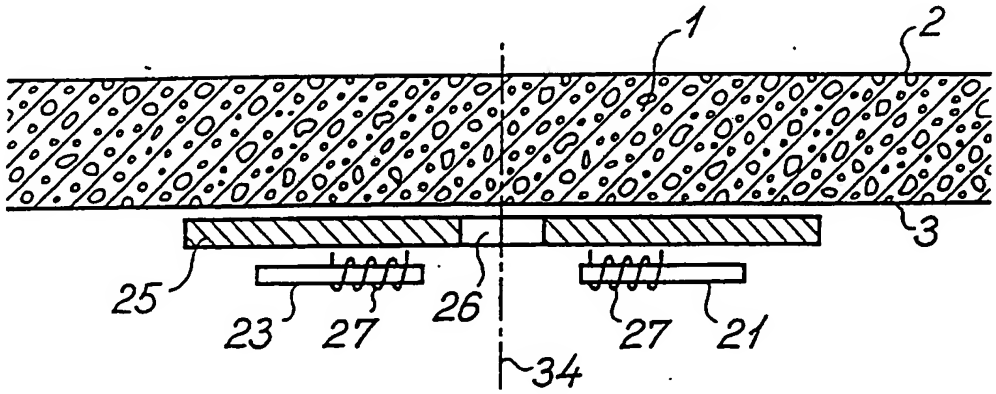
(54) Title: METHOD AND APPARATUS FOR LOCATING OPPOSITE POINTS ON THE TWO SIDES OF A PLANAR ELEMENT SUCH AS A STRUCTURAL BARRIER



(57) Abstract

An apparatus to locate points situated on opposite sides of a structural barrier comprises a transmitter (10) emitting electromagnetic waves in an axis symmetrical field in such way that the field symmetry axis (9) enters the structural barrier through a point of origin (4) at the structural barrier first surface and perpendicular hereto, and a locating receiver (20) comprising at least two receiver antennas (21, 23). The transmitter is arranged temporarily fixed on the given location at the point origin and powered, while an operator moves the receiver, watching an indicator unit (28) connected to the receiver antennas, said indicator unit showing when the receiver antenna is located exactly at the axis of the field emitted. The invention also defines a method corresponding to the apparatus described.

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TITLE: Method and Apparatus For Locating Opposite Points On the Two Sides of A Planar Element Such as A Structural Barrier

This invention concerns a method and a device for determining the position or locating that point on a surface of a planar element with parallel sides, such as a structural barrier, which point is located directly opposite a point of origin on the opposite surface of the planar element.

By numerous construction jobs on old as well as on new constructions or buildings it is of great importance to be able to locate oppositely situated points on the two sides of a plate, such as a wall, a partition, a roof, or a floor, for instance for the purpose of establishing through passages. By the establishment of passages through a such structural barrier, for instance for electric cabling, piping, or air ducts, there may be several obstacles on both sides of the structural element that block or limit those areas wherein passages may be established. In those cases where the circumstances are difficult with limited possibilities for making a passage on one side of the structural element, whereas the circumstances are less critical on the opposite side, a craftsman will naturally choose to drill the passage starting from the most critical side. In practical construction work there may, however, be many cases where the circumstances are difficult on both sides and where a mislocated piercing operation can be most inapropriate, and maybe even dangerous, for instance by the inadvertent drilling into electric cabling. An accurate determination of directly oppositely located points on the two sides of a structural element is therefore often of great importance.

To establish a such pair of points geometrical surveying is commonly used, which surveying relies upon access to existing passages through the structural barrier or around this barrier, e.g. openings or pipe passages or the like. The surveying may, however, be relatively difficult in such instances where there are no such passageways nearby the point of interest, and since there may be several other obstacles interfering with lines of sight or measuring lines.

Craftsmen sometimes also use to knock on the structural barrier on one side, an observer on the opposite side then trying to establish the

corresponding point. This method is, however, not very accurate.

Direction finding by radio signals is a known technique, and such methods could in principle be applied to solve the problem described. The equipment herefor is, however, relatively complicated, not easily used, and not very accurate.

The invention provides a novel apparatus of the above indicated general kind comprising a transmitter part and a receiver part, which transmitter part is capable of transmitting a rotationally symmetrical electromagnetic field through the structural element in such way that the axis of field symmetry passes through the point of origin on the structural element first side and is essentially perpendicular to the structural element surface. The receiver part comprises two receiver antennas, each of which antennas has a rotationally symmetrical sensitivity curve, these antennas being arranged with a fixed mutual spacing and with coincident axes of symmetry, and essentially parallel to the structural element second side surface, and wherein the signals received are processed in such way as to indicate generally continually whether a signal is received and to indicate in particular whether the two antennas receive signals of equal magnitude, but oppositely directed.

An electromagnetic field of the type described in principle defines the point desired exactly, and may be generated with limited electric power so that the necessary transmitter equipment may be built relatively simple.

The pair of receiver antennas define a plane perpendicular to the structural element surface plane, and a receiver device capable of detecting and indicating whether a signal is received and indicating very accurately whether the symmetry axis of the transmitter field is located in the receiver antenna symmetry plane or not, can be provided quite simply. To use the receiver equipment an operator moves or turns the receiver antennas along the structural element second surface until a such plane is established, which plane may then be marked onto the said second surface, whereafter the operator must once more move the receiver antennas and establish one further plane, whereafter the point of interest is located.

According to a preferred embodiment the receiver part indicates the power of the signal received. By such indication is obtained that the operator may immediately determine whether he moves, respectively turns, the antenna closer to or further away from the plane sought. This

facilitates the practical use of the equipment.

According to another preferred embodiment two pairs of receiver antennas are arranged on a common holder or base so that the symmetry axes of the two pairs are situated in different directions, which directions according to the invention are both essentially parallel to the structural element second surface, and which axes may, for instance, be situated mutually perpendicular. Hereby it is possible to determine simultaneously two planes and their line of intersection, whereby the point sought after may be located more rapidly.

The invention further provides a method similar to the apparatus described. Hereby advantages are obtained similarly to the above described.

Further features and advantages of the invention will appear from the following detailed specification by reference to the drawings, wherein

figure 1 is a sectional view of a transmitter according to the invention placed at a structural barrier,

figure 2 shows a planar view of a receiver according to the invention with a single pair of antennas,

figure 3 shows a section view through the receiver from figure 2,

figure 4 shows a receiver with two pairs of antennas,

figure 5 shows a structural barrier with the transmitter active from the structural barrier first side and a receiver antenna shown in three different positions a, b, and c on the structural barrier second side, and

figure 6 shows a plot of received signal power versus displacement of the receiver antenna.

In figure 1 a transmitter according to the invention, generally designated 10, is shown, said transmitter being capable of transmitting a rotationally symmetrical electromagnetic field with a symmetry axis 9. The transmitter comprises a transmitter antenna 11, e.g. a cylindrical ferrite rod, wherearound a conventional electric coil 12 is arranged, said coil being connected to cables 14, by which current from a transmitter generator 15 may be fed to the coil. The generator operation can be controlled by control means, such as push buttons 16. The transmitter antenna 11 is held in any convenient way so that the transmitted field

symmetry axis is perpendicular to the structural barrier. To facilitate the practical use, the transmitter antenna may e.g. be attached to a plate 13 by attachment means 18, said plate serving the main purpose to facilitate the orientation of the transmitter antenna direction to make it perpendicular to the structural barrier 1 surface 2. The antenna rod may be arranged in direct contact with the structural barrier 1, but may alternatively be arranged with a distance herefrom, as shown in the figure 1, wherein a hole 19 is arranged in the plate. With this design is obtained the practical advantage that the point where the axis of the emitted field enters the structural barrier surface 2 is directly visible. Hereby it becomes very simple to position the transmitter antenna immediately above a point of origin marked on the surface 2. The field of interest emitted from the transmitter antenna is what is known in the art as the near-field, i.e. a dipole field, which is here partly indicated by field lines 17.

In the preferred embodiment the generator 15 emits a signal oscillating at a frequency of 20 kHz and with a power of 500 mW. The choice of this frequency is essentially governed by regulatory standards as this frequency ensures that the transmitter will not interfere with any authorized radio communication. Obviously various other frequencies would be technically equally well suited. The transmission power of 500 mW has by practical experiments proved sufficient, allthough different power ratings obviously could be used.

In a practical embodiment the generator is battery powered and equipped with a timer system so as to emit power during a predetermined period of time, e.g. five minutes, upon activation of the control button, whereafter the transmitter automatically turns off in order to conserve energy.

A receiver comprising a single pair of antennas 21 and 23 is shown in planar view in figure 2, respectively in section and placed upon a structural barrier in figure 3. The antennas may, e.g., comprise two cylindrical ferrite rods arranged along a common axis and fitted with electrical coiling 27 connected to a detector unit 28. The receiver antennas are conveniently attached to a plate 25, and the receiver detector 28 could obviously also be attached to the same plate 25. The receiver antenna sensitivity characteristics together define a mid plane perpendicular to the symmetry axis of their sensitivity characteristics and essentially located at the mid point between the receiver antennas. In

the figure the mid plane is indicated by a dashed line 34, and the plate 25 is conveniently provided with a hole 26 or some other physical marking, such as notches 36 and 37 at the mid plane to make it possible, for instance with a pencil, to mark the line established directly onto the structural barrier surface 3.

The receiver detector 28 is equipped with a display 29, for instance a lamp, and the detector is further provided with a control button 35, whereby the operation may be turned on and turned off. The receiver could alternatively be constructed with all passive components, in which case no control button is necessary.

The signals from the two antennas 21 and 23 are summed in the detector 28 and subjected to suitable signal processing, such as amplification and filtering tuned to the transmitter frequency, and rectification, whereafter a net electric signal is obtained, which will here be called the detector signal. Hereby is obtained that, if the two antennas are subjected to essentially similar, but oppositely directed signals, they will balance out so that the detector signal becomes nill. The detector signal is indicated to the operator in a suitable way, for instance by turning on and turning off a lamp, dependent upon the presence of the detector signal.

In a preferred further embodiment a simple power indication related to the signal received is provided, for instance by varying the luminous power of the lamp related to the power of the detector signal.

Obviously other ways of detector signal presentation could be used, such as a meter (pointer instrument), a bar graph or an acoustic indication.

The practical use of the equipment will now be explained by reference to figures 5 and 6. In figure 5 a transmitter is shown on the first side of the structural barrier, said transmitter emitting an axis symmetrical field passing through the structural barrier. On the structural barrier second side 3 are shown three receivers marked a, b, and c. This represents for practical purposes the same receiver, but located in three different positions. When the receiver is at position a the two antenna coils will generate signals in a first common direction. When the receiver is arranged at position c both antenna coils will provide signals in a direction opposite the direction of the signals at the point a. Since the field is an oscillating alternating field, and since the receiver according to the invention has been provided with a simple

power indication, it is by the net detector signal not possible to establish any difference between the signals received at position a, respectively position c. In position b, however, the two coils receive fields that are essentially similar, but oppositely directed, and since the receiver sums these signals, the net signal detected is zero.

Figure 6 shows a graph of the detector signal power plotted versus the receiver antenna position. It may be seen that the signal power, when the antenna from some remote point approaches the axis of the field emitted, slowly rises until a point rather close to the transmitter antenna axis, whereafter the detector signal power drops sharply to zero. If the receiver antenna is moved further in the same direction, the signal power rises steeply on the opposite side of the transmitter antenna axis, whereafter it slowly decreases again. It can further be seen that the region, wherein the signal power drops to zero, is relatively narrowly defined. By moving the antenna in the direction along the axis of its sensitivity characteristics a clear and very accurate indication of the receiver antenna location, where the mid plane merges with the axis of the field transmitted, is thereby produced.

It could be presumed that the fact that the signal power indicated disappears at the mid point would lead to the false conclusion that the transmitter was inoperative or that the receiver antenna was remote from the field. Practical experiments have, though, proved that such doubt does not arise during practical use since the field near the mid point varies steeply, causing even a small motion of the receiver antenna to produce immediately a powerful signal.

When the receiver antenna is properly placed as explained, a line may be marked onto the structural barrier surface, which line will pass through the point sought after. Hereafter the receiver antenna is turned around an axis perpendicular to wall, and the process is repeated, whereafter a new line is established, which will also pass the point sought after, and which may also be marked onto the wall surface. Hereby the point sought after is established, being the point of line intersection.

It will be obvious to those skilled in the art that the apparatus could be used in an alternative way since it is equally well possible to keep the receiver antenna on essentially the same position and turn it around an axis perpendicular to the barrier, until a line is established containing the point sought after. Hereafter the antenna is moved to a

different position, and the process is repeated to establish a second line, whereby the problem has been solved. The apparatus described is equally well suited for either of these ways of use.

In figure 4 another embodiment of the receiver according to the invention is shown. The parts identical to those of the receiver of figure 2 are here indicated by the same references. The receiver of figure 4 comprises four receiver antennas 21, 22, 23, and 24. They are arranged in pairs, antenna 21 and antenna 23 forming a first pair with an axis called the x-axis, whereas the antennas 22 and 24 are located at a hereto perpendicular axis called the y-axis. The coils around antenna 21 and 23 are here connected in series so as to produce a sum signal fed to the detector for the x-axis 30. The coils of the antennas 22 and 24 are similarly connected in series to produce the sum signal to be fed to the detector for the y-axis 32. The x-axis detector 30 has a display 31 in the form of a luminous emitting diode and a control button 36, whereas the y-axis detector 32 has a display 33 and a control button 37. It is obvious that each of the antenna pairs with each their associated detector operates essentially exactly as described with reference to the receiver of figure 2 so that further detailed description of their function is not necessary. By the receiver of figure 4 it is possible very quickly to establish the point sought after, since the receiver, e.g., may be turned until one of the detector lamps turns out, thereby establishing a direction or a line passing the point sought after. If, e.g., the x-axis display lamp turns out, the point sought after must be located along the direction of the y-axis, and the receiver antenna may thereafter be moved parallel to the y-axis, until also the y-display lamp turns out. The receiver antenna is then located exactly at the point sought after, which may immediately be marked by a pencil through the hole 26 and the plate 25.

An apparatus according to the invention has been tested in the field and used by contractors, who expressed great content with the apparatus, and who found it very easily applicable and a very efficient and helpful tool for its purpose at construction work.

CLAIMS

1. Method to determine that point (5) on a surface of a plate (1) with parallel sides, such as a structural barrier, located oppositely a point of origin (4) on the plate opposite surface (2), characterized by transmitting a rotationally symmetrical electromagnetic field from the surface (2) and passing through the plate in such way that the axis of field symmetry passes the point of origin (4) essentially perpendicularly to the plate surface, by arranging two receiver antennas, each having axis symmetrical sensitivity characteristics with a fixed mutual spacing and coincident axes of symmetry and essentially parallel to the plate surface (3), processing the signals received in such a way as to indicate generally whenever a signal is received, and indicating in particular if the two antennas receive signals of essentially equal magnitude, but opposite directions.

2. Method according to claim 1, characterized by the receiver antennas being mechanically connected so that they can be displaced and turned and temporarily fixed while maintaining the fixed mutual spacing and mutual orientation.

3. Method according to claim 1, characterized by summing the signals received so as to indicate no signal if the two receiver antennas are located in fields that are essentially similar, but oppositely directed, whereas any other form of signal received is indicated.

4. Method according to claim 3, characterized by indicating the power level of the received summed signal.

5. Method according to claims 1-4, characterized by arranging two or more pairs of receiver antennas so as to have their axes of symmetry arranged in different directions.

6. Apparatus to determine the position of a point (5) on a surface (3) of a plate (1) with parallel sides (2), such as a structural barrier, which point is exactly opposite a point of origin (4) on the plate opposite surface (2), characterized by comprising an electric generator (15) capable of providing an alternating electric signal, a

transmitter antenna (11) capable, when fed with an alternating, electric generator signal, of transmitting an axis symmetrical electromagnetic field, and at least one pair of receiver antennas (21, 23) with axis symmetrical sensitivity characteristics arranged so that their axes of sensitivity characteristics coincide, said receiver antennas being arranged with a fixed mutual spacing, and an indicator unit (28), which essentially indicates whenever a signal is received, and which in particular indicates if the said receiver antennas receive signals of equal magnitude, but opposite directions.

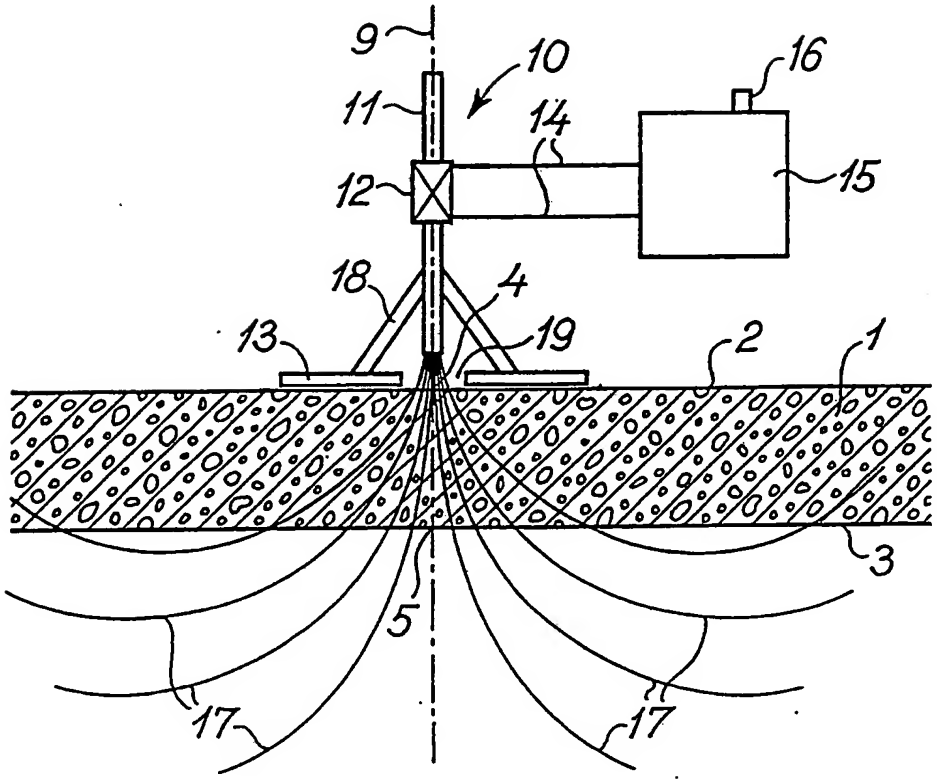
7. Apparatus according to claim 6, characterized by the pair of receiver antennas being attached to a common holder (25).

8. Apparatus according to claim 6, characterized by the indicator unit comprising a summation circuit, summing the signals for the two antennas of one pair before being indicated.

9. Apparatus according to claim 7 and 8, characterized by two or more pairs of receiver antennas being attached to a common holding device, but with different axis orientations.

10. Apparatus according to claims 7-9, characterized by the indicator, respectively the indicators comprising luminous emitting diodes, lighting relative to the power level of the signal received.

Fig. 1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17

Fig. 2

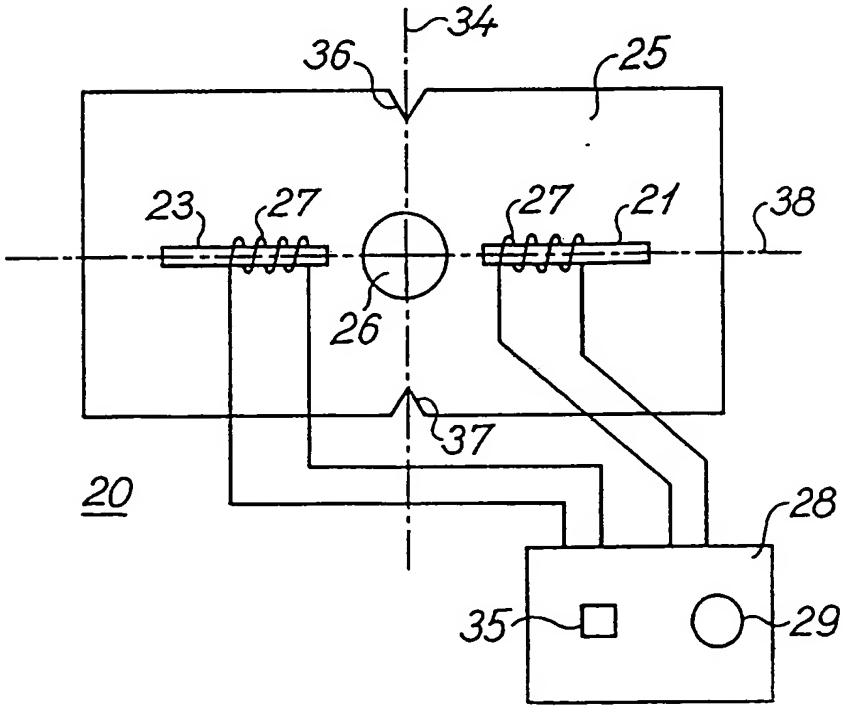
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Fig. 3

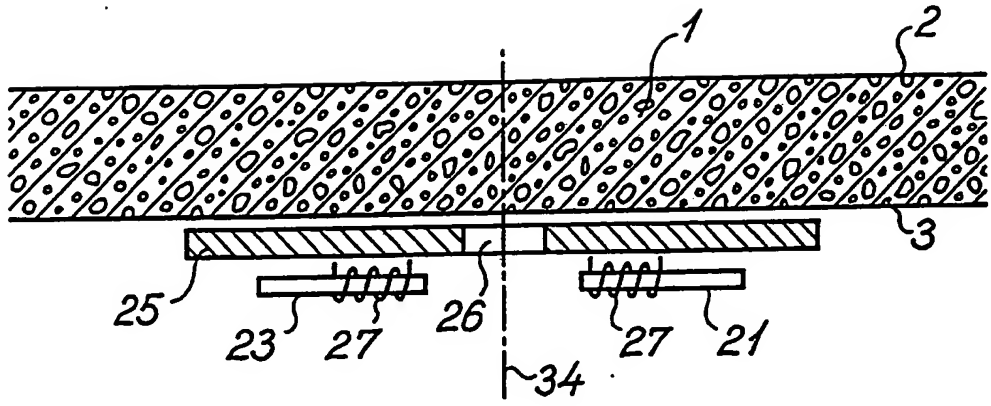


Fig. 4

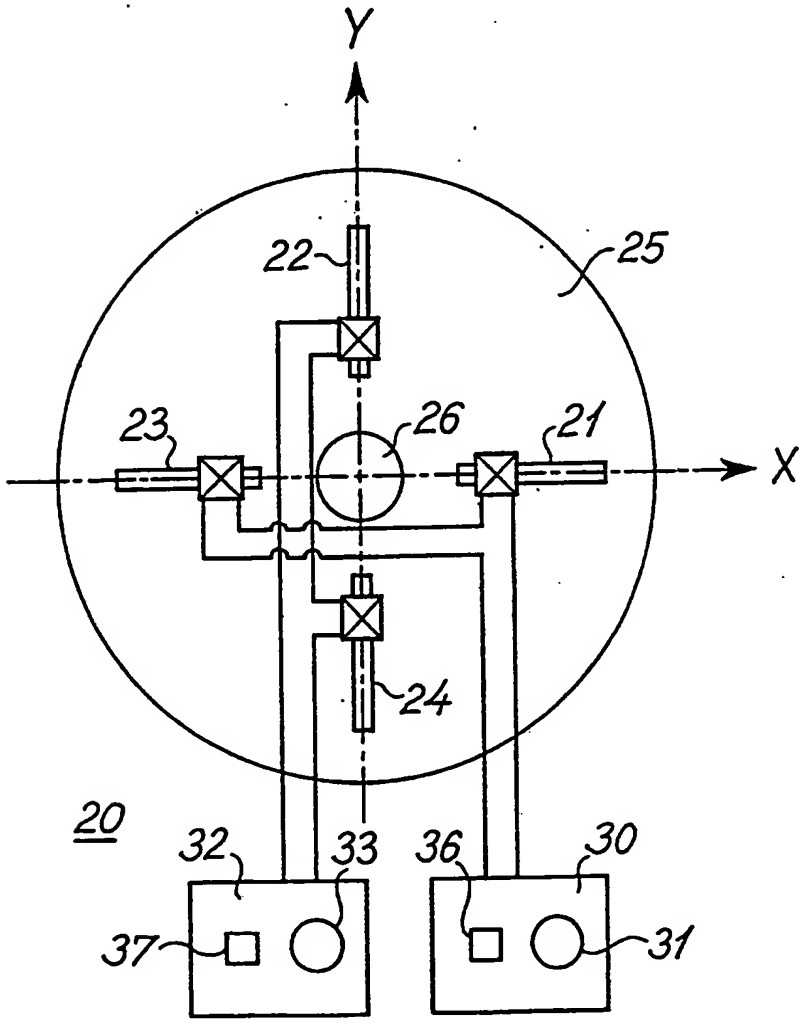


Fig. 5

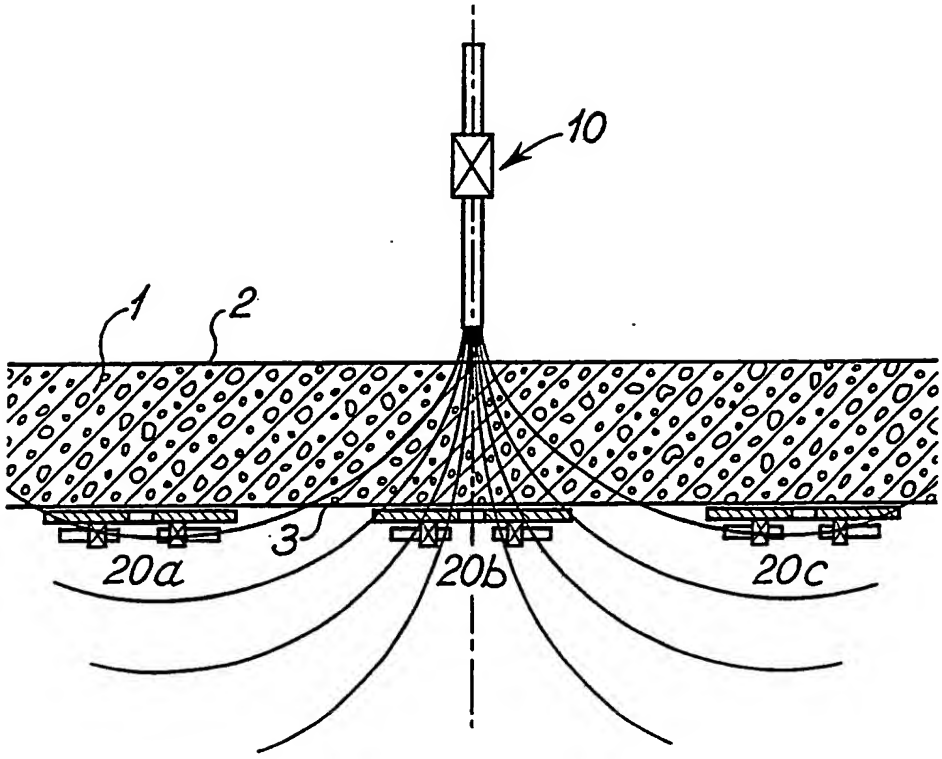
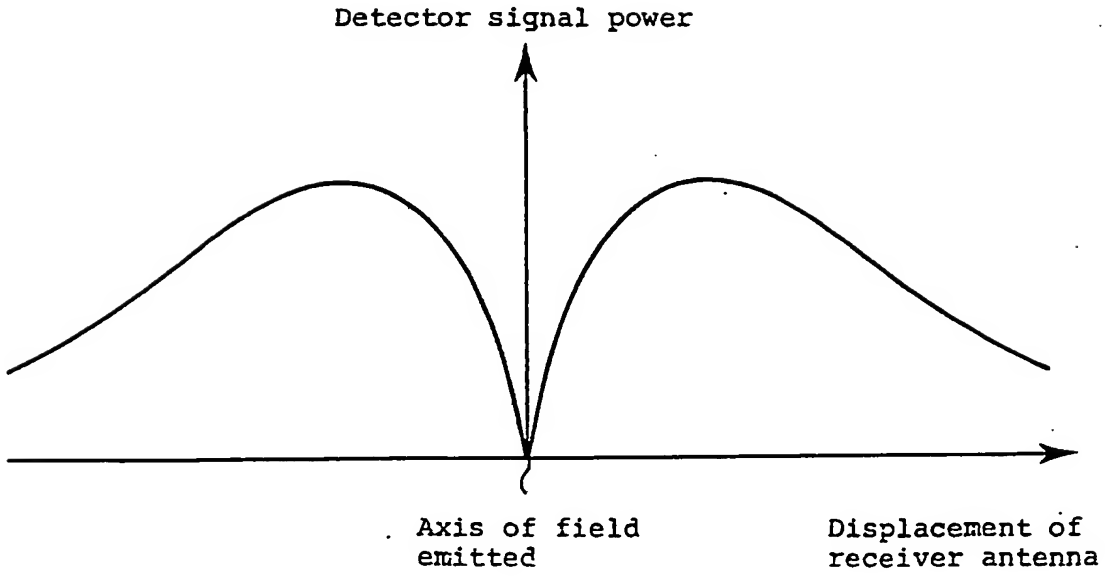

10
1
2
3
20a
20b
20c

Fig. 6


Detector signal power
Axis of field emitted
Displacement of receiver antenna

INTERNATIONAL SEARCH REPORT

PCT/DK88/00023

International Application No

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC 4

G 01 V 3/12

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC 4	B 25 H 7/00; G 01 S 1/00,/02,/68; G 01 V 3/08-/12
Nat Cl	21g:30/01-/03,/10
US Cl	116:114,204,209; 324:66,67; 340:258,282,686-88

Documentation Searched other than Minimum Documentation to the Extent that such Documents are included in the Fields Searched [8]

SE, NO, DK, FI classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
Y	US, A, 3 704 413 (BLEVINS) 28 November 1972 See figures 1-3 & US, 3836848	1,6
Y	DE, B, 1 109 281 (VEB INTRON LEIPZIG WERK FÜR INDUSTRIELLE ELEKTRONIK) 22 June 1961 See figure 1 and column 4, lines 10-14	1,6
A	DE, A1, 3 208 383 (WURMBACH GERT ET AL) 15 September 1983	
A	US, A, 1 971 189 (GENERAL ELECTRIC COMPANY) 21 August 1934	
A	US, A, 2 807 780 (B.E. LUDWIG ET AL) 24 September 1957	
A	US, A, 4 388 890 (WESTER ET AL) 21 June 1983	

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
1988-05-03	1988 -05- 05
International Searching Authority	**Signature of Authorized Officer**
Swedish Patent Office	Bengt Jonsson

SP

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III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
A	US, A, 4 464 622 (FRANKLIN) 7 August 1984	